

**IN THE UNITED STATES DISTRICT COURT  
FOR THE DISTRICT OF MASSACHUSETTS  
BOSTON DIVISION**

STUDENTS FOR FAIR ADMISSIONS, INC.,

*Plaintiff,*

v.

PRESIDENT AND FELLOWS OF  
HARVARD COLLEGE,

*Defendant.*

Civil Action No. 14-14176 (ADB)

**BRIEF OF ECONOMISTS MICHAEL P. KEANE, HANMING FANG,  
YINGYAO HU, GLENN C. LOURY, JOHN P. RUST,  
AND MATTHEW S. SHUM  
AS *AMICI CURIAE* IN SUPPORT OF STUDENTS FOR FAIR ADMISSIONS**

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### **INTEREST OF *AMICI CURIAE*<sup>1</sup>**

*Amici* are leading economists and econometrics scholars who have extensively studied and written about discrete choice modeling and econometrics tools of the kind used by the experts in this case and are professionally interested in the proper use of such tools. Several of the *amici* filed a brief during the summary judgment phase of this case that explained, *inter alia*, that the statistical model used by the plaintiff's expert, Dr. Peter Arcidiacono, is methodologically sound. See Br. of Economists Michael P. Keane *et al.* in Support of Students for Fair Admissions, Doc. 450 (Jul. 30, 2018) (Br. of Dr. Keane *et al.*). Biographies of all *amici* are summarized in Exhibit A to this brief.

As this brief explains, the evidence presented at trial supports the conclusions set forth in the first brief. *Amici* respectfully disagree with the counterarguments set forth by Harvard's expert, Dr. David Card, and by Harvard's supporting academic *amici* with regard to these statistical issues. See Amended Br. of Professors of Economics as *Amici Curiae* in Support of Def., Doc. 531 (Sept. 6, 2018) (Amended Br. of Dr. Akerlof *et al.*).

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<sup>1</sup> Counsel for *amici curiae* state that (1) this brief was authored by counsel for *amici curiae* and not by counsel for any party, in whole or in part; (2) no party or counsel for any party contributed money that was intended to fund preparing or submitting the brief; and (3) apart from *amici curiae* and their counsel, no person contributed money that was intended to fund preparing or submitting the brief.

## INTRODUCTION AND SUMMARY OF ARGUMENT

*Amici* agree with Dr. Arcidiacono on several significant statistical questions at issue in this case.

1. Dr. Arcidiacono correctly excluded the personal rating from his admissions model. Dr. Arcidiacono's regressions show that the personal rating is significantly affected by race. Including the personal rating in the admissions model would therefore understate the importance of race in Harvard's admission decisions. Excluding the personal rating corrects for this bias. Dr. Card's proposed alternative, which would penalize Asian Americans for their concededly superior academic and extracurricular accomplishments, is unsound.

Importantly, as Dr. Card has acknowledged, if the personal rating is excluded from his own preferred model of admissions, that model shows statistically significant discrimination against Asian Americans in Harvard's admission process.

2. Dr. Arcidiacono's admissions model correctly accounts for racial disparities in Harvard's treatment of applicants whom it categorizes as disadvantaged. Harvard's *amici* suggest that Dr. Arcidiacono lacked an acceptable *a priori* rationale to account for this racial disparity in the model. However, Dr. Arcidiacono's testimony shows adequate *a priori* rationales for doing so.

3. Dr. Arcidiacono reasonably excluded so-called ALDC applicants (athletes, legacy applicants, Dean's List and Director's List applicants, and children of Harvard faculty and staff) from the baseline data sample used in his admissions model. These applicants benefit from personalized attention and unusual

advantages that are not extended to other applicants in Harvard’s admissions process. In other words, the ALDC applicants are not similarly situated to other applicants. This justified Dr. Arcidiacono’s decision to exclude the ALDC applicants from his baseline sample.

## ARGUMENT

### I. DR. ARCIDIACONO CORRECTLY EXCLUDED THE PERSONAL RATING FROM HIS ADMISSIONS MODEL.

#### A. Dr. Arcidiacono’s regression model of Harvard’s personal rating shows that it is significantly influenced by race.

The parties’ central statistical-modeling dispute has to do with the “personal rating” assigned by Harvard’s admissions officers. *See* Br. of Dr. Keane *et al.* at 4; *see generally id.* at 3–13. The parties dispute whether the personal rating should be included as a control variable in the statistical models of Harvard’s admissions process (“admissions models”) used by the experts in this case. SFFA argues that the personal rating is affected by race, and thus that its inclusion as a control variable in the admissions models would understate the importance of race in Harvard’s admissions decisions. Pl.’s Proposed Findings of Fact and Conclusions of Law ¶ 63, Doc. 620 (Dec. 19, 2018) (SFFA’s Proposed Findings). Harvard argues that the personal rating is not affected by race. Harvard’s Proposed Findings of Fact and Conclusions of Law ¶¶ 131–145, Doc. 619 (Dec. 19, 2018) (Harvard’s Proposed Findings).

To test whether the personal rating is affected by race, it is necessary to develop a separate multiple regression model that isolates the effect of race on the

personal rating, while, to the extent feasible, “*holding other applicant characteristics constant.*” James H. Stock & Mark W. Watson, Introduction to Econometrics 381 (3<sup>rd</sup> ed. 2011) (italics in original). Dr. Arcidiacono developed such a model of the personal rating; Dr. Card made adjustments to Dr. Arcidiacono’s model, but did not construct his own independent model of the rating. T13.188:23–189:11, T9.150:2–10, T9.95:2–5.

Dr. Arcidiacono’s model of the personal rating supports the inference that race plays a role in scoring the personal rating. T9.96:5–98:14. The model coefficients for Asian-American applicants are significant and negative. PD38.30, 33 (coefficient -0.398). This means that Asian-American applicants score significantly worse than white applicants on the personal rating, other things equal. T9.95:11–96:4. By contrast, the model coefficients for African-American applicants and Hispanic applicants are significant and positive, meaning that they score significantly better on the personal rating than white applicants, other things equal. PD38.30, 33 (coefficients +0.682 and +0.279). The regression coefficients support the inference that just like the overall rating—a rating that both parties agree is affected by race—the personal rating assigned by Harvard is “significantly influenced by race.” T9.96:5–12.<sup>2</sup>

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<sup>2</sup> These coefficients are derived from the “baseline” data sample, but it is worth noting that the coefficients derived from the “expanded” sample that includes legacies, Dean’s List and Director’s List applicants, and children of faculty and staff are nearly identical, and produce nearly identical results. Rebuttal Expert Report of Peter S. Arcidiacono, Doc. 415-2, Ex. B, Tables 6.1R, B.6.12.R (Arcidiacono Rebuttal).

The model supports an inference that significant weight is given to race when scoring the personal rating—in other words, that the personal rating is significantly affected by race. To illustrate the magnitude of the bias, Dr. Arcidiacono calculated the probability that the personal-rating scores would change to a 2 or lower if race did not affect the personal rating, a lower score being better. P1.6–7 (personal-rating scores rank from “1. Outstanding” to “6. Worrisome personal qualities”). If the personal rating was not affected by race, the probability of Asian-American applicants receiving a 2 or better on the personal rating would increase from 17.8% to 21.6%, a 21% increase in their probability of receiving a 2 or better. PD38.31. By contrast, the probability of African-American or Hispanic applicants receiving a 2 or better would drop: from 19.3% to 15.2% for African-American applicants, a 21% decrease, and from 19.2% to 16.8% for Hispanic applicants, a 12% decrease. *Id.* The magnitude of these effects supports an inference that Harvard gives significant weight to an applicant’s race when scoring the personal rating. T9.98:5–14.

**B. The observable data do not justify an inference that Dr. Arcidiacono’s personal-rating model suffers from omitted-variable bias.**

Harvard and its *amici* suggest that because Dr. Arcidiacono’s model of the personal rating does not include qualitative data considered by Harvard, this “may cause race to be credited with an effect that is actually caused by the excluded [unquantified] variable.” Amended Br. of Dr. Akerlof *et al.* at 14; Harvard’s Proposed Findings ¶ 131 (same). Harvard and its *amici* argue “that factors outside the data—not racial bias—explain the associations Dr. Arcidiacono found between

Asian-American ethnicity” and the personal rating. Harvard’s Proposed Findings ¶ 140. In short, they argue that Dr. Arcidiacono’s model of the personal rating suffers from omitted-variable bias. This criticism is unpersuasive.

Omitted-variable bias arises *only* when (1) a relevant explanatory variable (here, race) is significantly correlated with a missing variable (here, the unobserved qualitative data that allegedly inform the personal rating), and (2) the missing variable significantly affects the outcome variable (here, the personal-rating score). *See* Stock & Watson, *supra* at 231. A model should not be rejected simply because it is “missing data.” “That would be the downfall of empirical economics . . . because all models have unobservables.” TR9.81:18–21 (Arcidiacono); *see also* Stock & Watson, *supra* at 322 (“Missing data are a common feature of economic data sets.”). To reject a model, there must be at least a *substantial* risk that the missing data are causing a bias in the model’s estimated coefficients, such that inferences drawn from the coefficients are likely misleading. *See* Br. of Dr. Keane *et al.* at 7–8, 13.

Harvard and its *amici* have not shown that there is a substantial risk that missing data are causing omitted-variable bias in Dr. Arcidiacono’s model of the personal rating.

*First*, Harvard’s *amici* argue that Dr. Arcidiacono’s model “included no adequate control variables regarding the content of . . . recommendation letters.” Amended Br. of Dr. Akerlof *et al.* at 13; *cf.* Harvard’s Proposed Findings ¶ 148.<sup>3</sup> But

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<sup>3</sup> Harvard’s *amici* also reference “personal essays.” *Id.* On this topic, please see Br. of Dr. Keane *et al.* at 9–10, 12.

Dr. Arcidiacono's model includes control variables for Harvard's school-support ratings, which comprise two teacher-recommendation ratings and a counselor-report rating. TR9.98:16–24. There is no reason to think that these ratings are inadequate controls for recommendation letters. There is also no reason to think that recommendation letters are likely to be a significant source of omitted-variable bias in the personal-rating model. Indeed, Asian-American applicants do much better than African-American applicants and Hispanic applicants and only slightly worse than white applicants in the school-support ratings. P621; P623.

*Second*, Harvard and its *amici* suggest that the fact that white applicants do slightly better than Asian-American applicants on the school-support ratings supports Dr. Card's argument that the personal rating is not racially biased. *See* Harvard's Proposed Findings ¶ 139; D692.3–4; Amended Br. of Dr. Akerlof *et al.* at 15. This suggestion confuses the key question—whether the personal rating is racially biased—with a narrower question: whether the rating is biased against Asian Americans as compared with whites. The first question, not the second question, is the relevant question for purposes of determining whether the personal-rating variable should be excluded from the admissions model. As Dr. Card acknowledged at trial, a variable is correctly excluded as biased even if it only includes racial “tips,” i.e. preferences, for favored minority applicants. T14.79:13–14 (“If it was a pure tip based on the race alone, yes, I would say it should be excluded. Yes, I agree.”). Furthermore, the fact that whites have slightly higher scores than Asian Americans on the school-support ratings does not justify an inference that

Asian Americans score *substantially* worse than whites on other unobserved variables that influence the personal rating. Yet this is precisely the inference that would be necessary to conclude that unobserved variables could explain the substantially lower personal-rating scores of Asian-American applicants.

*Third*, Harvard and its *amici* argue that Asian-American applicants “were *less* strong than White applicants on factors in the data that could affect the personal rating.” Harvard’s Proposed Findings ¶ 138. To support this contention, Harvard and its *amici* rely on the “non-academic admissions index” prepared by Dr. Card, which “summarizes an applicant’s strength” with respect to “non-academic factors.” Amended Br. of Dr. Akerlof *et al.* at 15; *see* Harvard’s Proposed Findings ¶ 139; *see also* T13.70:9–72:19; DD.10.77–78; D692.1. But the non-academic admissions index is flawed in two critical respects.<sup>4</sup>

The first flaw is that the index is derived from Dr. Card’s admissions model, not from a model of how Harvard actually scores the personal rating. T13.70:3–5 (“what I did was I took my overall admissions model and I isolated all the factors in that model that are non-academic components”). The index does not explain how Harvard weighs non-academic factors when it scores the personal rating, because it is centered on the wrong outcome variable for that purpose: admissions, not

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<sup>4</sup> In addition, Harvard and its *amici* here are again conflating the key question—whether the personal rating is racially biased—with the narrower question whether the rating is biased against Asian Americans vis-à-vis whites.

personal-rating scores. The index thus does not justify any conclusions with respect to the personal rating.

The second flaw in the index is that it does not reflect all of the observable data that inform the personal rating, including the academic data. Dr. Card testified that academic variables “explain a relatively modest fraction of the overall variation in the personal rating.” T13.63:15–18; *see* DD10.76. Even if the effect of the academic variables on the personal rating is properly characterized as “modest,” academic variables should not be omitted. Asian-American applicants do significantly better on academic variables than white applicants. PD38.5; P621; P623. Given this fact, removing even the “modest” effect of academic variables on the personal rating causes significant omitted-variable bias against Asian Americans.

By contrast, Dr. Arcidiacono’s regression containing *all* of the relevant data that inform the personal rating, including academic data, reliably shows that Asian-American applicants are virtually indistinguishable from white applicants in the observable factors that inform the personal rating, and stronger than African-American applicants and Hispanic applicants. PD38.33 (Asian American Observable +0.020; African American Observable -0.374, Hispanic Observable -0.268); *see also* Arcidiacono Rebuttal, Table B.6.12R (similar results for the expanded data sample). As Dr. Arcidiacono testified, because Asian Americans are relatively strong on the observables that affect the personal rating, econometric theory suggests that they are also likely to be relatively strong on the unobservable

“missing data” that inform the personal rating. T9.103:2–25.<sup>5</sup> Unobservables such as personal essays are thus unlikely to affect the bottom-line conclusion that the personal rating is racially biased and should be excluded from the admissions model.

*Fourth*, the stark racial disparity observed in the personal rating assigned by Harvard’s Office of Admissions is not replicated in the personal rating assigned by Harvard’s alumni with the benefit of in-person interviews. Harvard alumni do not score Asian-American applicants significantly lower than other applicants on the personal rating. *See* Br. of Dr. Keane *et al.* at 2, 7, 11–12; P621; P623. This evidence further suggests that unobserved variables are unlikely to explain the lower personal ratings that the Office of Admissions assigns to Asian-American applicants.

In short, Dr. Arcidiacono’s personal-rating model does not suffer from a significant risk of omitted-variable bias.

**C. Because the personal rating is biased, Dr. Arcidiacono was correct to exclude it from the admissions model.**

The racial bias in the personal rating has an important effect on admissions. Roughly three-fourths of all of Harvard’s admitted applicants had a personal rating

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<sup>5</sup> Dr. Card and Harvard do not appear to dispute this general principle, even if they dispute the underlying facts. *See* T13.74:14–17 (Card) (noting that “economists often argue that if the observed factors inside the data that inform a particular variable are in one direction, then the unobserved factors may well be in that same direction”); Harvard’s Proposed Findings ¶ 137 (if Asian Americans are stronger on factors in the data that inform the personal rating, “it might be reasonable to assume Asian-American applicants were also stronger on factors outside the data that inform the [personal] rating”).

of 2 or better. P621; P623. Given the importance of scoring a 2 or better on the personal rating, failing to correct for this bias would cause the effect of race on admissions to be understated, diluting the effect of race on admissions and biasing the effect of race toward zero. This bias must be corrected by eliminating the incorrect measurement of race in the model's variables, if possible. *See* Stock & Watson, *supra* at 322.

Excluding the personal rating from the admissions model is a sound way to correct for this bias. Doing so eliminates the incorrect measurement of race in the admissions model. Neither Dr. Card nor Harvard's *amici* dispute the general soundness of this practice. Amended Br. of Dr. Akerlof *et al.* at 12 (explaining that "it was appropriate to exclude overall ratings from the model" because "the record suggests that admissions officers may consider race in assigning applicants' 'overall ratings'"); T13.82:23–83:21 (Card) (explaining that he excluded the overall rating from his own model because he "didn't want to include a variable . . . that's affected by race per se"); T14.77:22–78:4 (Card) (agreeing that it is inappropriate to include any variables that themselves can be affected by race); *see also* Report of David Card, Doc. 419-33, Ex. 33 at 10 (Card Report) ("it is a well-accepted statistical practice to exclude variables from a regression model that may themselves be directly influenced by the variable of interest (here, race)").

Dr. Card did not propose any sound, unbiased alternative to excluding the personal rating. Indeed, Dr. Card surprisingly suggested that the proper way to control for racial bias in the personal rating would be to selectively penalize Asian-

American applicants (and *only* Asian-American applicants) by artificially lowering their actual academic and extracurricular ratings. T13.78:14–81:17; DD10.81–83; D694; *see also* Harvard’s Proposed Findings ¶¶ 143–144 (same). This proposal does not appear to have a sound methodological basis. Both experts agree that the gap between Asian Americans’ academic and extracurricular ratings and the observable data reflects superior academic and extracurricular achievements that are not observed in the numerical data, not racial bias in favor of Asian Americans. T9.108:24–109:8, 110:3–17 (Arcidiacono); T14.83:7–15, 85:9–13, 102:6–22 (Card). In the absence of racial bias, the “gap” between the observables and the academic and extracurricular ratings should not be eliminated by artificially lowering the academic and extracurricular ratings for Asian Americans. That would remove important data from the model for no defensible methodological reason. Indeed, doing so would manufacture omitted-variable bias to tilt the admissions model against Asian Americans.

In sum, Dr. Arcidiacono’s decision to exclude the personal rating from his regression model of the admissions process was methodologically sound, and Dr. Card did not offer any persuasive alternative to doing so.<sup>6</sup>

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<sup>6</sup> Harvard’s *amici* suggest that Dr. Arcidiacono lacked any “compelling reason to exclude” personal ratings because he “did not identify any *a priori* qualitative evidence that admissions officers consider an applicant’s race in assigning personal ratings.” Amended Br. of Dr. Akerlof *et al.* at 12–13. But the trial record contains significant qualitative evidence indicating that at least some of Harvard’s admissions officers consider race when they score the personal rating. *See generally* SFFA’s Proposed Findings ¶¶ 94–128.

**D. Excluding the personal rating shows statistically significant bias against Asian Americans in Harvard's admissions process.**

It is important to emphasize that if the personal rating is excluded from the experts' admissions models, the models will show statistically significant discrimination against Asian Americans in Harvard's admissions process. Indeed, as Dr. Card has conceded, if the personal rating is excluded from *his own preferred admissions model*, that model shows statistically significant discrimination against Asian Americans.

Harvard's *amici* suggest that two alternative analyses performed by Dr. Card show that even if the personal rating is excluded from his model of admissions, there would be no statistically significant evidence of bias against Asian Americans. Amended Br. of Dr. Akerlof *et al.* at 18. This suggestion is mistaken.

*First*, as Dr. Card has conceded, excluding the personal rating from his preferred model suffices to show statistically significant evidence of discrimination against Asian Americans in Harvard's admission process. T14.81:2–13; T14.9:17–23.

*Second*, the two alternative analyses cited by Harvard's *amici* do not change the basic conclusion that excluding the personal rating from the admissions model means that the model will indicate racial discrimination. As Dr. Card acknowledged, the first alternative actually shows statistically significant discrimination against Asian Americans. T14.8:10–13. As for the second alternative, it is the unsound model discussed above that selectively penalizes Asian-American applicants (and only Asian-American applicants) by artificially lowering their

academic and extracurricular ratings. *See supra* at 11–12. Like Dr. Card, Harvard’s *amici* do not seriously argue that the academic and extracurricular ratings are biased in favor of Asian Americans, so this unsound model should not be credited as a genuine alternative.

In short, if the personal rating is excluded from the admissions models, that suffices to infer statistically significant discrimination against Asian Americans in Harvard’s admissions process.

**II. DR. ARCIDIACONO CORRECTLY CONCLUDED THAT INTERACTIONS BETWEEN RACE AND “DISADVANTAGED” STATUS SHOULD BE INCLUDED IN HIS MODEL.**

Dr. Arcidiacono was correct to use an interaction term to account for the interaction between race and the “disadvantaged” status that Harvard’s Office of Admissions assigns to some applicants. *See Br. of Dr. Keane et al.* at 14–16; *see also* SFFA’s Proposed Findings ¶¶ 90–92. Harvard’s *amici* contest this conclusion, suggesting that Dr. Arcidiacono had no *a priori* rationale for including the interaction term. Amended Br. of Dr. Akerlof *et al.* at 16–18. This suggestion is not persuasive.

As Dr. Arcidiacono testified at trial, he had two *a priori* rationales for including the interaction term in his model of admissions. T9.85:15–18. First, prior reports by Harvard’s Office of Institutional Research indicated that “you got a different tip for being low income depending on your race.” T9.85:25–86:11. Second, in his past work on affirmative action in higher education, Dr. Arcidiacono had found evidence of similar race-based differential treatment of disadvantaged

applicants. T9.85:18–22. These *a priori* rationales justified including the interaction term.

Harvard’s *amici* also argue that Dr. Card included an interaction term in an alternative analysis that shows no statistically significant discrimination. Amended Br. of Dr. Akerlof *et al.* at 19. However, the alternative analysis includes the biased personal rating. *See* Rebuttal Report of David Card, Doc. 419-37, Ex. 37 at 56–57, Ex. 15. A model that includes the biased personal rating is not reasonable, so this alternative analysis is irrelevant. The alternative analysis also assumes that all of Dr. Card’s other statistical-modeling choices are appropriate, an issue that is disputed by the parties.

**III. DR. ARCIDIACONO CORRECTLY CONCLUDED THAT SPECIAL-RECRUITING-CATEGORY APPLICANTS, WHO ARE NOT SIMILARLY SITUATED TO OTHER APPLICANTS, SHOULD BE EXCLUDED FROM THE SAMPLE IN HIS MODEL.**

Dr. Arcidiacono reasonably decided to remove so-called ALDC applicants—recruited athletes, legacy applicants, applicants on the Dean’s List or Director’s List, and children of faculty and staff—from the baseline data sample used in his admissions model. *See* Br. of Dr. Keane *et al.* at 16–18; *see also* SFFA’s Proposed Findings ¶¶ 69–77.

Harvard’s *amici* disagree with Dr. Arcidiacono’s decision to exclude ALDC applicants from the sample, questioning “whether there was a valid *a priori* rationale for this exclusion.” Amended Br. of Dr. Akerlof *et al.* at 9. But the disproportionate admissions rates of ALDC applicants, PD38.2, taken together with other data (e.g., their disproportionate chance of receiving a staff interview,

PD38.3), provide sufficient evidence to justify an inference that these applicants are not in the same population because they are given special advantages in Harvard's admissions process.

The evidence at trial supports the conclusion that ALDC applicants are differently situated. *See generally* SFFA's Proposed Findings ¶¶ 69–77. For example, Harvard sets aside a number of interview slots for recruited athletes each year. T5.184:3–11. In addition, as a matter of Harvard policy, only recruited athletes receive a score of 1 in the athletic rating. P1.6; T1.163:19–164:1, T3.224:11–14. It is reasonable to infer that these advantages help explain why recruited athletes have a remarkably high admission rate of 86% (compared with an admissions rate of 6% for all other applicants). PD38.2. Along the same lines, Harvard's admissions officers testified that unlike other applicants, ALDC applicants may receive interviews outside of the typical timeframe (September to November) during which Harvard publicly advertises that it provides interviews. T5.184:12–16. ALDC applicants thus "are much more likely to get staff interviews." T10.67:17–18; *see* P619. There is also evidence that applicants on the Dean's List and Director's List receive special, personalized attention. *See* SFFA's Proposed Findings ¶ 69. Such advantages justify excluding ALDC applicants from the baseline data sample.

## CONCLUSION

For the foregoing reasons, the Court should conclude (1) that Dr. Arcidiacono correctly excluded the personal rating from his admissions model; (2) that Dr. Arcidiacono correctly used an interaction term to account for racial disparities in how Harvard treats “disadvantaged” students; and (3) that Dr. Arcidiacono reasonably excluded ALDC applicants from the baseline data set used in his admissions model.

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**CERTIFICATE OF SERVICE**

I hereby certify that this document filed through the CM/ECF system will be sent electronically to the registered participants as identified on the Notice of Electronic Filing.

/s/ Randall B. Clark  
Randall B. Clark

# **Exhibit A**

*AMICI CURIAE*

*Note:* Institutional affiliations are provided for identification purposes only.

**Michael P. Keane** is Professor of Economics and Australian Laureate Fellow at the University of New South Wales. Previously, Professor Keane was Professor of Economics at the University of Minnesota, New York University, and Yale University, and the Nuffield Chair of Economics at Oxford. He is a member of the Council of the Econometric Society and Chair of the Australasian Regional Standing Committee of the Econometric Society. Professor Keane is recognized as a leading expert on discrete choice modeling, human capital investment, the economics of education, and consumer demand. He has published roughly 100 articles in leading journals in both economics and management science and has received numerous honors, including the John D.C. Little Award, the Kenneth J. Arrow Award, the Dennis J. Aigner Award, and the Australian Federation Fellowship. He is also a Fellow of the Econometric Society, a Fellow of the Journal of Econometrics, and a Founding Fellow of the International Association for Applied Econometrics.

**Hanming Fang** is Class of 1965 Term Professor of Economics at the University of Pennsylvania and a Research Associate at the National Bureau of Economic Research (NBER). Previously, Professor Fang held faculty positions at Yale University and Duke University. Professor Fang is an applied microeconomist with broad theoretical and empirical interests focusing on public economics. His research covers topics ranging from discrimination, social economics, psychology and economics, and welfare reform to public good provision mechanisms, auctions, health insurance markets, and population aging. He is a Fellow of the Econometric Society. In 2008, he received the Kenneth J. Arrow Award. He has been a co-editor for leading economics journals, including the Journal of Public Economics and the International Economic Review, and has served on the editorial board of numerous journals.

**Yingyao Hu** is Professor of Economics at Johns Hopkins University. Previously, Professor Hu held a faculty position at the University of Texas at Austin. Professor Hu is an econometrician and an applied microeconomist with research interests in micro-econometrics, empirical industrial organization, and labor economics. His research covers topics ranging from identification and estimation methods for microeconomic models with latent variables, such as ability, belief, effort, and unobserved heterogeneity, to empirical topics including auctions, learning behavior and subjective beliefs, unemployment rates, and fertility decisions. He is a leading expert on measurement error models. He has published many articles in leading journals in both economics and statistics. Since 2013, he has been a Fellow of the Journal of Econometrics.

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